MITSUI OIL FIELD

LUBRICANTS • OILS • GREASE

THE COMPLETE HANDBOOK OF

LUBRICANT SCIENCE

A practical reference guide to base oils, viscosity, industry classifications, oil and grease selection, and technical data sheets.

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1. Introduction to Lubrication Science

Lubrication is the science of reducing friction, heat, and wear between two surfaces in relative motion by introducing a film of material — the lubricant — between them. Though it appears simple on the surface, lubrication science draws on chemistry, physics, and materials engineering to keep engines, gearboxes, bearings, and hydraulic systems running efficiently for thousands of hours under extreme pressure, temperature, and contamination. This handbook is designed to give every engineer, technician, purchaser, and end user a clear, practical, and complete understanding of lubricant fundamentals — from base oil chemistry to reading a technical data sheet.

1.1 Why Lubrication Matters

Every moving mechanical assembly generates friction. Left unmanaged, friction converts useful mechanical energy into heat, accelerates surface wear, and eventually leads to component failure. A well-selected and well-maintained lubricant addresses four core functions simultaneously, and a fifth in specialised applications:

- **Friction reduction —** separating moving metal surfaces with a fluid or semi-fluid film so they never make direct contact under normal operating conditions.
- **Wear protection —** preventing metal-to-metal contact during startup, shutdown, and boundary lubrication conditions where the oil film is thinnest.
- **Heat dissipation —** carrying heat away from friction points to a reservoir or cooler, keeping components within safe operating temperatures.
- **Contaminant control —** suspending dirt, metal fines, and combustion by-products so they can be filtered out rather than embedding in bearing surfaces.
- **Sealing and corrosion protection —** forming a barrier against moisture and acidic by-products, and in the case of piston rings, helping maintain compression.

1.2 The Regimes of Lubrication

The way a lubricant protects a surface changes with speed, load, and temperature. Understanding these regimes explains why viscosity and additive chemistry both matter.

- **Boundary lubrication —** occurs at low speed, high load, or startup. The oil film is too thin to fully separate surfaces, so anti-wear and extreme-pressure (EP) additives chemically bond to metal surfaces to prevent scoring.
- **Mixed lubrication —** a transitional regime where the film partially separates surfaces; both viscosity and additive chemistry share the protective load.
- **Hydrodynamic (full-film) lubrication —** at higher speeds, a continuous fluid film fully separates the surfaces and viscosity becomes the dominant protective factor.
- **Elastohydrodynamic lubrication (EHL) —** found in rolling-element bearings and gear teeth, where contact pressure is high enough to momentarily and elastically deform the surfaces, thinning and thickening the oil film accordingly.

ENGINEERING INSIGHT

A lubricant is only as good as its weakest regime. A gear oil may perform beautifully in hydrodynamic conditions at speed, but if it lacks EP additives it can fail catastrophically at the boundary-lubrication moment of startup — which is why additive package selection is just as important as viscosity selection.

1.3 What a Lubricant Is Made Of

Every finished lubricant, whether an engine oil, hydraulic fluid, or grease, is built from two components:

1. **Base oil (70–99% of the formulation) —** the foundation fluid, either refined from crude petroleum (mineral), chemically synthesised (synthetic), or blended from both. The base oil primarily determines viscosity, oxidation stability, and low-temperature behaviour.
2. **Additive package (1–30% of the formulation) —** a precisely balanced chemistry of detergents, dispersants, anti-wear agents, viscosity index improvers, antioxidants, corrosion inhibitors, and pour-point depressants that give the finished lubricant its performance characteristics and allow it to meet OEM and industry specifications.

The chapters that follow work through each of these building blocks in turn — starting with how base oils are classified into Groups I through V, then moving through viscosity, service classifications, oil types, grease chemistry, key performance properties, and finally how to read a technical data sheet with confidence.

2. Base Oils: Group I to Group V

Every finished lubricant starts life as a base oil. In 1993, the American Petroleum Institute (API) established a five-group classification system based on sulphur content, saturate content, and viscosity index (VI). This classification lets formulators and buyers compare base stocks on a like-for-like basis regardless of which refinery produced them.

Group	Manufacturing Process	Sulphur	Saturates	Viscosity Index
I	Solvent refining	> 0.03%	< 90%	80 – 120
II	Hydrocracking	≤ 0.03%	≥ 90%	80 – 120
III	Severe hydrocracking / hydro-isomerisation	≤ 0.03%	≥ 90%	≥ 120
IV	Chemical synthesis (PAO)	—	100%	typically 130 – 150
V	All other base stocks (esters, PAG, naphthenics, etc.)	varies	varies	varies

2.1 Group I — Solvent-Refined Mineral Oil

Group I base oils are produced by solvent refining of crude petroleum, a relatively unsophisticated process that removes some, but not all, of the undesirable aromatics and sulphur compounds. They contain the highest proportion of impurities among the five groups and the widest, least consistent molecular structure. Group I oils are inexpensive and remain in use today for less demanding applications — general industrial oils, some older engine oil formulations, and process oils — but they are steadily being phased out in favour of Group II as refineries modernise.

2.2 Group II — Hydrocracked Mineral Oil

Group II base oils are produced by hydrocracking, a process that uses hydrogen under heat and pressure to remove sulphur, nitrogen, and unstable molecules, and to convert aromatics into more stable saturated compounds. The result is a clearer, more chemically stable oil with better oxidation resistance than Group I, at a similar cost. Group II is now the most widely produced base oil worldwide and forms the backbone of most modern conventional engine oils, hydraulic oils, and industrial lubricants.

2.3 Group III — Severely Hydrocracked / Hydro-Isomerised Oil

Group III base oils undergo a more intense hydrocracking and hydro-isomerisation process, achieving a viscosity index of 120 or higher — a level of performance once achievable only through chemical synthesis. Because their performance rivals true synthetics at a lower production cost, Group III oils are legally marketed as “synthetic” or “full synthetic” in most markets, including India and the United States, even though they originate from crude oil rather than a chemical synthesis reaction. Group III is the dominant base stock behind most modern full-synthetic and synthetic-blend engine oils.

BUYER'S NOTE

The word “synthetic” on a label does not always mean Group IV (PAO). Group III oils are legitimately labelled synthetic in most regulatory jurisdictions because they meet the performance threshold, not because of their manufacturing route. Always check the technical data sheet for the actual base stock and performance specification rather than relying on the label alone.

2.4 Group IV — Polyalphaolefins (PAO)

Group IV base oils are true synthetics, built molecule-by-molecule through the catalytic polymerisation of alpha-olefins derived from ethylene. Because their molecular structure is engineered rather than refined from a naturally variable crude source, PAO delivers a uniform, predictable molecular chain with excellent low-temperature fluidity, a very high viscosity index, outstanding oxidation and thermal stability, and low volatility. PAO is the base stock of choice for premium full-synthetic engine oils, aviation lubricants, extreme-temperature industrial applications, and long-drain hydraulic and compressor oils.

2.5 Group V — All Other Base Stocks

Group V is the catch-all category for any base stock that does not fit Groups I through IV. This includes esters (used for their excellent lubricity and biodegradability), polyalkylene glycols or PAG (used in compressor oils for their resistance to hydrocarbon dilution), silicones, naphthenic oils (used in transformer and process oils for their excellent low-temperature and solvency properties), and phosphate esters (used as fire-resistant hydraulic fluids). Group V oils are rarely used alone; they are more commonly blended in small percentages with Group III or IV base stocks to enhance seal compatibility, additive solubility, or biodegradability.

2.6 Choosing Between Base Oil Groups

In practice, the choice of base oil group is a balance of performance requirement, operating temperature range, oil-drain interval targets, and cost. As a general rule of thumb:

- **Group I/II —** adequate for moderate-duty applications, standard drain intervals, and cost-sensitive industrial use.
- **Group III —** the default choice for modern passenger and commercial vehicle engine oils seeking extended drain intervals and strong all-round performance at a reasonable cost.
- **Group IV —** selected for extreme temperature ranges, high-load equipment, and applications where extended oil life and minimal deposit formation are critical, such as turbines, aviation, and premium industrial gear drives.
- **Group V —** used as a functional additive or blend component rather than a standalone base oil, except in specialised fire-resistant or biodegradable formulations.

3. Understanding Viscosity and SAE Grades

Viscosity is a fluid's resistance to flow — informally, its “thickness.” It is the single most important physical property of any lubricant, because it directly governs how well a fluid film separates moving surfaces, how easily an oil pump can circulate it, and how a lubricant behaves across the temperature range it will actually see in service.

3.1 Kinematic Viscosity and cSt

Kinematic viscosity is measured in centistokes (cSt) at a reference temperature, most commonly 40°C and 100°C. A technical data sheet will almost always list both values. The 40°C figure describes how the oil behaves near typical operating or storage temperature, while the 100°C figure reflects behaviour once the lubricant has fully warmed up in service — a more meaningful indicator of protection under running conditions.

3.2 Viscosity Index (VI)

Viscosity naturally drops as temperature rises and increases as temperature falls. The Viscosity Index is a unitless number describing how much a lubricant's viscosity changes across a temperature range — the higher the VI, the more stable the viscosity, and the better the oil performs across a wide operating temperature window. Conventional mineral oils typically have a VI between 80 and 120; synthetic PAO and high-quality Group III oils can exceed 140. A high-VI oil is especially valuable in equipment that must start cold and then run hot, such as vehicle engines and outdoor hydraulic systems.

3.3 The SAE Viscosity Grading System

The Society of Automotive Engineers (SAE) publishes the viscosity grading standards used worldwide for engine oils (SAE J300) and gear oils (SAE J306). These are performance classifications based purely on flow behaviour at specified temperatures — they say nothing about additive quality or service performance, which is instead governed by API, ACEA, or OEM specifications covered in the next chapter.

Engine Oil Grades (SAE J300)

A multigrade engine oil label such as 15W-40 or 5W-30 communicates two pieces of information in one code:

- **The ‘W’ number (Winter grade) —** describes cold-cranking and pumping viscosity at low temperature. A lower W number (0W, 5W) means the oil stays fluid and pumpable at colder temperatures, allowing easier cold starts and faster oil delivery to critical components.
- **The second number —** describes the oil's viscosity once it has reached 100°C operating temperature. A higher number (40, 50) indicates a thicker, more shear-resistant film suited to higher loads, higher ambient temperatures, or older/high-mileage engines; a lower number (20, 30) reflects a thinner film that reduces friction and improves fuel economy in modern, tighter-tolerance engines.

SAE Grade	Typical Use Case
0W-20 / 0W-16	Modern passenger cars designed for maximum fuel economy in cold and temperate climates

SAE Grade	Typical Use Case
5W-30	The most common modern passenger and light commercial vehicle grade
10W-30 / 10W-40	Older engines, warmer climates, or manufacturers specifying a thicker running film
15W-40	Heavy-duty diesel engines, commercial trucks, and off-highway equipment
20W-50	High-temperature climates, older or high-mileage engines needing extra film strength

Gear Oil Grades (SAE J306)

Gear oils use a separate, numerically similar but not interchangeable grading scale, most commonly seen as 75W-90 or 80W-140. These numbers are not directly comparable to engine oil grades of the same figure — an 80W-90 gear oil is substantially thicker than a 20W-50 engine oil despite the smaller numbers, because gear oil viscosity is measured against a different reference scale suited to the boundary-lubrication conditions found in gear meshes and differentials.

Industrial Oils — the ISO VG System

Industrial lubricants such as hydraulic, gear, compressor, and turbine oils are not graded on the SAE scale at all. Instead, they use the ISO Viscosity Grade (ISO VG) system defined by ISO 3448, which specifies kinematic viscosity in cSt at 40°C directly — an ISO VG 46 hydraulic oil has a viscosity of 46 cSt ± 10% at 40°C. Common industrial grades include ISO VG 32, 46, 68, 100, 150, and 220, each matched to specific equipment manufacturer recommendations.

PRACTICAL TIP

Never select a lubricant by viscosity grade alone. Always cross-check against the equipment manufacturer's specification sheet, since two fluids with the same cSt number can differ significantly in additive chemistry and suitability for a given application.

4. API and Industry Service Classifications

Where SAE grades describe how an oil flows, service classifications describe how well it performs — its ability to control deposits, resist oxidation, protect against wear, and remain compatible with modern emissions equipment. These classifications are what separates a lubricant that merely meets a viscosity number from one that will genuinely protect an engine or gearbox over its full service life.

4.1 What Is API?

The American Petroleum Institute (API) is the body that defines minimum performance standards for engine oils sold in North America and referenced globally. API classifications appear as a two-letter code: the first letter denotes fuel type, and the second denotes the performance tier, with later letters in the alphabet representing newer, more stringent standards.

- **'S' Series (Spark-ignition / petrol engines) —** for example SN, SN Plus, SP — each generation adds tighter control over deposits, oxidation, low-speed pre-ignition (LSPI), and compatibility with modern turbocharged direct-injection engines.
- **'C' Series (Compression-ignition / diesel engines) —** for example CI-4, CJ-4, CK-4, FA-4 — each generation is driven largely by emissions regulation, adding protection suited to exhaust gas recirculation (EGR), diesel particulate filters (DPF), and selective catalytic reduction (SCR) systems.

A newer API category is generally backward-compatible with equipment specifying an older category of the same letter series, though the reverse is not always true — always confirm backward compatibility against the OEM's owner manual before substituting.

4.2 Other Major Classification Bodies

Body	Region / Scope	Typical Codes
API	United States / global reference	SN, SN Plus, SP, CK-4, FA-4
ACEA	European passenger and commercial vehicles	A3/B4, C2, C3, E6, E9
ILSAC	Japanese/US passenger car fuel-economy focus	GF-5, GF-6A, GF-6B
JASO	Japanese motorcycle and diesel-specific standards	MA, MA2, DH-2
OEM	Manufacturer-specific approvals	MB 229.5, VW 504.00, Volvo VDS-4.5

ACEA (European Automobile Manufacturers Association) categories are especially important to understand because the letter groups map to distinct engine designs rather than simply newer-is-better tiers: the 'A/B' series covers petrol and light-duty diesel passenger cars, the 'C' series covers low-SAPS (low ash, phosphorus, sulphur) oils formulated for compatibility with catalytic converters and particulate filters, and the 'E' series covers heavy-duty diesel engines.

4.3 Industrial Equivalents

Industrial lubricants — hydraulic, gear, compressor, and turbine oils — are governed by their own standards rather than API's automotive scale, most commonly:

- **ISO 6743 —** classifies industrial lubricants by application family (e.g. ISO-L-HM for anti-wear hydraulic oil, ISO-L-CKC for industrial gear oil).
- **DIN 51524 —** the German standard widely referenced for hydraulic oil performance tiers HL, HLP, and HVLP.
- **AGMA 9005 —** the American Gear Manufacturers Association standard for industrial gear lubricants.

4.4 Reading a Specification Correctly

A finished lubricant may legitimately claim several classifications at once — for example, an engine oil labelled “API SP / ACEA A3/B4 / MB 229.5” has been formulated and tested to satisfy all three bodies simultaneously. When selecting a lubricant, match the classification exactly to the equipment manufacturer's current specification rather than assuming a “higher” or newer classification is automatically suitable — some newer low-SAPS formulations, for instance, are unsuitable for older engines that require higher zinc and phosphorus anti-wear additive levels.

KEY DISTINCTION

SAE grade tells you how the oil flows. API/ACEA/OEM classification tells you how well it protects. A lubricant needs the correct answer to both questions — never select on viscosity grade alone.

5. Types of Lubricating Oils and Their Applications

Beyond the base oil group and viscosity grade, lubricants are formulated into distinct product families, each engineered around the specific mechanical demands of the equipment it protects. This chapter surveys the major oil families a purchaser or technician is likely to encounter.

5.1 Hydraulic Oil

Hydraulic oil is the working fluid inside hydraulic systems — it transmits power, lubricates pumps, valves, and cylinders, dissipates heat, and prevents corrosion, all at the same time. Most hydraulic oils are anti-wear (AW) formulations, denoted ISO-L-HM, containing zinc dialkyldithiophosphate (ZDDP) or ash-less anti-wear additives to protect high-pressure pump components. Key properties to check on a hydraulic oil's data sheet include ISO viscosity grade (commonly VG 32, 46, or 68), viscosity index, oxidation stability, demulsibility (the ability to shed water rather than emulsify it), and air release value.

- **HL —** basic mineral oil with oxidation and corrosion inhibitors, for light-duty, low-pressure systems.
- **HM —** the industry-standard anti-wear hydraulic oil for most mobile and industrial equipment.
- **HV —** a high-viscosity-index anti-wear oil for equipment exposed to wide ambient temperature swings, such as outdoor construction machinery.
- **Fire-resistant fluids (HFC, HFDU) —** water-glycol or phosphate-ester based fluids used near ignition sources such as die-casting and steel mill equipment.

5.2 Compressor Oil

Compressor oils lubricate the pistons, rotors, or screws of air and gas compressors while managing the heat of compression. Because compressed air often carries oil carryover downstream, compressor oils are formulated for low volatility (to minimise oil consumption and carbon deposit formation) and strong oxidation resistance, since compression heat accelerates oil breakdown. Rotary screw compressors typically specify synthetic PAO or PAG-based oils for extended service life (4,000–8,000 hours), while reciprocating compressors more commonly use premium mineral or semi-synthetic oils. Refrigeration compressors require entirely separate, refrigerant-compatible fluid families such as POE (polyol ester) or PAG oils matched to the specific refrigerant gas in use.

5.3 Gear Oil

Gear oils protect the sliding and rolling contact between meshing gear teeth, where loads are extremely high and lubrication frequently falls into the boundary regime. Most industrial and automotive gear oils are EP (extreme pressure) formulations containing sulphur-phosphorus additive chemistry that reacts with the metal surface under heat and pressure to form a sacrificial protective layer, preventing scuffing and micro-pitting. Common families include mineral EP gear oils (GL-4, GL-5 for automotive differentials), synthetic industrial gear oils for enclosed drives and gearboxes, and open gear compounds for large, exposed gear sets such as those found in mining and cement equipment.

5.4 Synthetic, Mineral, and Semi-Synthetic (Blend) Oils

These three terms describe the base oil composition of a finished lubricant, and they cut across all the product families above — a hydraulic oil, gear oil, or engine oil can each be offered in mineral, semi-synthetic, or full-synthetic form.

Type	Base Composition	Characteristics
Mineral	Group I or II base oil	Lowest cost; adequate performance for moderate duty and standard drain intervals
Semi-synthetic / Blend	Mineral blended with Group III or IV	Improved oxidation stability and temperature range at moderate cost premium
Full synthetic	Group III, IV, or V base oil	Best oxidation stability, temperature range, and extended drain interval; highest cost

The choice between them is rarely about which is universally "better" — it is about matching total cost of ownership to the duty cycle. A stationary industrial gearbox running in a temperature-controlled plant with easy access for frequent oil changes may be well served by a quality mineral oil; a remote, high-load, or temperature-extreme application will recover the higher upfront cost of a synthetic through extended drain intervals, reduced downtime, and lower wear-related maintenance.

5.5 Other Common Oil Families

- **Turbine oil —** very high oxidation stability and rapid air/water separation for steam and gas turbines, typically rated for 20,000+ hours of service.
- **Transformer oil —** highly refined naphthenic or synthetic esters providing dielectric insulation and heat transfer inside electrical transformers.
- **Way oil / slideway lubricant —** high-tackiness oils designed to cling to vertical or inclined machine tool slideways without dripping, while resisting the stick-slip motion that causes poor machining precision.
- **Chain and open gear oils —** high-adhesion formulations for exposed chains and gears where fling-off and washout resistance matter more than fine filtration.
- **Metalworking fluids —** cutting oils, coolants, and forming lubricants that manage heat and friction at the tool-workpiece interface during machining.

6. Grease: Composition, Thickener Types, and Selection

Grease is not simply “thick oil.” It is a solid-to-semi-fluid product formed by dispersing a thickening agent within a liquid lubricant, along with additives to impart special properties. Grease is chosen over fluid oil wherever a lubricant needs to stay in place — vertical surfaces, slow-speed bearings, seals with imperfect sealing, or components that are lubricated infrequently and cannot be continuously re-oiled.

6.1 The Three Components of Grease

3. **Base oil (typically 70–95%) —** the same mineral, synthetic, or blended base oils covered in Chapter 2, which “bleed” slowly out of the thickener structure to lubricate the contact surface during operation.
4. **Thickener (typically 3–20%) —** a soap or non-soap gelling agent that forms a fibrous, sponge-like matrix holding the base oil in suspension until mechanical or thermal energy releases it.
5. **Additives (typically 1–10%) —** anti-wear, extreme-pressure, corrosion inhibitor, antioxidant, and tackifier chemistries tailored to the grease's intended application.

6.2 Thickener Types Compared

The thickener is the single biggest driver of a grease's performance envelope — its temperature range, water resistance, pumpability, and compatibility with other greases. Mixing incompatible thickener types can destroy the structure of both greases, causing softening or hardening and loss of lubrication, so thickener type should always be checked before topping up an unfamiliar system.

Thickener	Max Temp	Water Resistance	Typical Use
Calcium (lime)	~60–80°C	Excellent	Low-cost general purpose, wet environments, low-speed / low-load
Sodium	~120–140°C	Poor	Older-generation wheel bearing grease; largely superseded
Lithium	~120–130°C	Good	General purpose, automotive and industrial multi-service grease
Lithium Complex	~150–180°C	Good	Heavy-duty, high-temperature, wheel bearings, high-load industrial
Calcium Sulfonate	~150–177°C	Excellent	Marine, extreme wet/corrosive environments, heavy-duty EP applications
Aluminium Complex	~150–160°C	Excellent	Food-grade, water-washout resistant, marine applications
Polyurea	~150–177°C	Good	Sealed-for-life bearings, electric motor bearings (long oxidation life)
Clay / Bentonite (non-soap)	180°C+	Good	Extreme high-temperature, no defined melting point

6.3 Wheel Bearing Grease Specifically

Wheel bearing grease deserves special mention because it operates in one of the most demanding combined environments in a vehicle: moderate-to-high temperature from braking heat, constant rotation, and frequent water exposure from road spray and washing. Modern wheel bearing greases are almost universally lithium complex or calcium sulfonate based, formulated to NLGI grade 2 consistency with strong extreme-pressure additives and excellent water washout resistance (tested to ASTM D1264). Using an unsuitable grease — for example a soft, low-temperature calcium grease — in a wheel bearing application risks the grease softening and flinging out of the bearing under heat and centrifugal force, leading to premature bearing failure.

6.4 NLGI Consistency Grades

Grease firmness is graded on the NLGI (National Lubricating Grease Institute) consistency scale, measured by how far a standard cone penetrates the grease sample in tenths of a millimetre — a softer grease allows deeper penetration and receives a lower NLGI number.

NLGI Grade	Consistency	Typical Application
000 – 00	Semi-fluid	Centralised lubrication systems, gearboxes, enclosed housings
0 – 1	Very soft to soft	Low-temperature and centralised systems, cold climates
2	Medium (most common)	General purpose bearings, wheel bearings, industrial machinery
3	Firm	High-speed bearings, vertical applications resisting slump
4 – 6	Very firm to hard block	Specialised, rarely used outside niche sealing applications

6.5 Choosing the Right Grease

A correctly specified grease should match five factors simultaneously: the thickener's temperature range against the equipment's actual operating temperature, water and washout exposure, load (standard vs. extreme-pressure formulation), speed (using the bearing's speed factor, or DN value, to avoid channeling or excessive churning), and compatibility with whatever grease is already present in the system. When in doubt, always consult the equipment manufacturer's lubrication chart and the grease's technical data sheet rather than substituting on price alone.

7. Key Lubricant Properties and Test Methods

Technical data sheets report a lubricant's properties using standardised test methods, almost always referencing ASTM (American Society for Testing and Materials) or equivalent ISO/DIN test numbers. Understanding what each property measures — and why it matters — is essential to comparing products meaningfully rather than by brand or price alone.

Property	Test Method	What It Tells You
Kinematic viscosity	ASTM D445	Flow resistance at 40°C and 100°C — core to grade selection
Viscosity Index (VI)	ASTM D2270	Stability of viscosity across temperature — higher is better
Flash point	ASTM D92	Lowest temperature at which vapours ignite — safety and volatility indicator
Pour point	ASTM D97	Lowest temperature the oil will still flow — cold-climate suitability
Total Base Number (TBN)	ASTM D2896	Reserve alkalinity to neutralise acidic combustion by-products (engine oils)
Total Acid Number (TAN)	ASTM D664	Acidity level — rising TAN signals oxidation and oil degradation
Demulsibility	ASTM D1401	Ability to separate cleanly from water rather than emulsifying
Foam tendency / stability	ASTM D892	Resistance to sustained foam that can cause cavitation and poor lubrication
Four-ball wear (scar diameter)	ASTM D4172	Anti-wear film strength under standardised sliding contact
Four-ball EP (weld point)	ASTM D2783	Maximum load the film withstands before metal-to-metal welding occurs
Dropping point (grease)	ASTM D566 / D2265	Temperature at which grease loses its structure and becomes fluid
NLGI consistency (grease)	ASTM D217	Cone-penetration firmness grading (000 to 6)

7.1 Flash Point and Pour Point in Practice

Flash point and pour point together define the practical temperature envelope of an oil in the field. A high flash point (commonly above 200°C for industrial oils) indicates lower volatility and safer handling near heat sources, while a low pour point (typically –15°C to –45°C for cold-climate hydraulic and gear oils) ensures the oil remains pumpable during a cold start rather than gelling in the sump or lines.

7.2 TBN and TAN — Reading the Health of In-Service Oil

TBN (Total Base Number) matters most in engine oils, where it represents the oil's remaining ability to neutralise acidic combustion by-products before they cause corrosion. A fresh oil might carry a TBN of 8–12; as the oil ages in service, TBN steadily depletes, and most maintenance programmes flag an oil for change once TBN falls below roughly half its fresh value or below a TAN cross-over point. TAN (Total Acid Number), conversely, rises as an oil oxidises and degrades — used together in oil analysis programmes, the TBN/TAN cross-over point is one of the most reliable single indicators that an oil has reached the end of its useful life.

7.3 Anti-Wear and Extreme-Pressure Performance

The four-ball wear test measures the scar diameter left on steel balls under standardised sliding contact, giving a comparative measure of a lubricant's anti-wear film strength during normal operation. The related four-ball EP (weld point) test pushes load progressively higher until the balls weld together, identifying the absolute limit of the extreme-pressure additive package — critical data for gear oils, greases, and any application with high shock-load potential.

7.4 Oxidation Stability

Oxidation is the single largest driver of lubricant end-of-life. Heat, oxygen, water, and catalytic metals (particularly copper) accelerate the breakdown of base oil molecules into acids, sludge, and varnish. Oxidation stability is typically assessed with methods such as the Rotating Pressure Vessel Oxidation Test (RPVOT, ASTM D2272), which reports the number of minutes an oil sample withstands oxidative pressure before failure — a higher RPVOT number indicates a longer expected service life, all else being equal.

HOW TO USE THIS CHAPTER

When comparing two competing lubricants, do not stop at viscosity grade and price. Line up their flash point, pour point, four-ball wear scar, and (where applicable) RPVOT or TBN figures side by side — these numbers reveal the real difference in protection and service life.

8. How to Read a Technical Data Sheet (TDS)

A Technical Data Sheet is the single most important document a buyer or engineer can consult before selecting a lubricant. It is a manufacturer's formal declaration of a product's typical properties, intended applications, and specification compliance. This chapter walks through each section of a typical TDS in the order it usually appears, and explains what to look for.

8.1 Product Identification

Every TDS opens with the product name, a brief description of the product family (e.g. “heavy-duty diesel engine oil” or “lithium complex EP grease”), and often a short marketing statement about its intended benefits. Confirm the exact product name and pack size match what is being quoted or delivered — manufacturers frequently sell closely related variants under similar names.

8.2 Specifications and Approvals

This section lists every industry body and OEM specification the product meets or is approved against — for example “API CK-4, ACEA E9, MB 228.31, MAN M 3477, Volvo VDS-4.5.” This is the section that confirms the oil is actually suitable for the target equipment, and it should always be checked against the equipment manufacturer's current lubricant specification before purchase.

8.3 Typical Physical and Chemical Properties Table

The heart of the TDS is a table of typical properties, each tied to a named test method (see Chapter 7). A well-prepared TDS will always cite the test method (e.g. “ASTM D445”) alongside each value, because the same property name can be measured differently between standards bodies.

Typical TDS Row	Example Value	Test Method
Kinematic viscosity @ 40°C	68 cSt	ASTM D445
Kinematic viscosity @ 100°C	8.6 cSt	ASTM D445
Viscosity Index	142	ASTM D2270
Flash point (COC)	230°C	ASTM D92
Pour point	–33°C	ASTM D97
Density @ 15°C	0.865 g/mL	ASTM D4052

Important: the word “typical” in “typical properties” is a legal and technical qualifier. It means the values shown are representative averages from production, not a guaranteed specification for every batch. Minor batch-to-batch variation within manufacturing tolerance is normal and expected.

8.4 Application Guidance

Most TDS documents include a short section describing recommended uses, sometimes with drain interval guidance, mixing/compatibility notes, and any equipment types the product is not suitable for. This section often contains the manufacturer's practical field experience and should not be skipped even by experienced buyers.

8.5 Handling, Storage, and Safety Notes

A responsible TDS will reference the accompanying Safety Data Sheet (SDS) for detailed handling, storage, and disposal information, and may include a brief note on recommended storage temperature range and shelf life — most industrial lubricants have a shelf life of 3–5 years in sealed, indoor, temperature-stable storage.

8.6 Revision Date and Version Control

Always check the date printed at the bottom of the TDS. Additive chemistry and specification approvals evolve over time, and manufacturers periodically reformulate products while keeping the same product name. A TDS more than two to three years old should be treated with caution — request the current version before making a purchasing decision on a specification-critical application.

FIVE-POINT TDS CHECKLIST

1) Confirm the exact product name. 2) Match specifications/approvals to your equipment's requirement. 3) Compare viscosity grade and VI against the OEM recommendation. 4) Check flash point and pour point against your operating environment. 5) Confirm the TDS revision date is current.

9. Storage, Handling, and Best Maintenance Practices

Even the best-specified lubricant will underperform if it is contaminated, stored incorrectly, or applied inconsistently. Industry studies consistently show that contamination — not additive depletion — is the leading cause of premature lubricant and equipment failure. This chapter covers the practical habits that protect the investment made in correctly specifying a lubricant in the first place.

9.1 Contamination Control

- **Particulate contamination —** dirt and wear metal fines act as an abrasive between moving surfaces, accelerating wear far faster than clean oil alone would allow. Store drums with bungs facing up and clean the area around the bung before opening.
- **Water contamination —** even 0.1% water can drastically reduce a lubricant's load-carrying ability and promote corrosion and microbial growth, especially in hydraulic and gear systems. Store drums indoors or under cover, never outdoors where water can pool on the lid.
- **Cross-contamination —** mixing incompatible additive packages or thickener types (see Chapter 6 for grease compatibility) can neutralise performance in both products. Use dedicated, clearly labelled transfer equipment for each product family.

9.2 Storage Best Practices

6. **Store indoors where possible,** in a covered, temperature-stable area away from direct sunlight and extreme temperature swings, which accelerate oxidation even in a sealed container.
7. **Maintain first-in, first-out (FIFO) rotation** using drum receipt dates, since even unopened lubricants have a finite shelf life.
8. **Keep drums sealed until use** and reseal promptly after dispensing to minimise moisture and dust ingress.
9. **Label everything clearly,** including product name, viscosity grade, and date received, to prevent accidental mis-application on the shop floor.

9.3 Oil Analysis and Condition Monitoring

Routine oil sampling and laboratory analysis is the most cost-effective predictive maintenance tool available. A typical used-oil analysis panel reports viscosity, TBN/TAN, water content, wear metals (iron, copper, aluminium, chromium), and particle count — trends across successive samples reveal developing problems long before they cause a breakdown, and allow drain intervals to be safely extended when the data supports it rather than relying on a fixed calendar interval alone.

9.4 Filtration and Cleanliness Codes

Hydraulic and high-precision systems specify a target cleanliness using the ISO 4406 code, expressed as three numbers (e.g. 18/16/13) representing the particle count per millilitre at three size thresholds (≥4µm, ≥6µm, ≥14µm). Lower numbers indicate cleaner oil. Maintaining the OEM-specified cleanliness code through proper filtration is often as important to component life as selecting the correct viscosity grade in the first place.

9.5 A Simple Lubrication Management Checklist

- Maintain a lubrication schedule matched to OEM-recommended intervals for each asset, not a single blanket interval across all equipment.
- Use dedicated, colour-coded or labelled equipment (funnels, grease guns, transfer pumps) for each lubricant type to prevent cross-contamination.
- Sample and test in-service oil at regular intervals appropriate to the equipment's criticality.
- Keep an up-to-date lubricant cross-reference chart so replacement personnel can quickly identify the correct product for each asset.
- Review technical data sheets annually against current OEM specifications, particularly for critical or high-value equipment.

CLOSING THOUGHT

Lubricant selection, storage, and monitoring together form a single discipline. A premium synthetic lubricant stored carelessly or contaminated in the field will underperform a correctly handled mineral oil — consistency of practice matters as much as the product itself.

10. Glossary of Key Terms

A quick-reference glossary of the terms used throughout this handbook, for fast lookup on the shop floor or in the field.

Term	Definition
Additive package	The blend of chemical compounds added to a base oil to achieve a finished lubricant's performance properties.
Anti-wear (AW) additive	A chemistry, commonly ZDDP, that forms a sacrificial protective film on metal surfaces under boundary lubrication conditions.
Base oil	The primary fluid component of a lubricant, before additives, classified into API Groups I–V.
Boundary lubrication	A lubrication regime where the oil film is too thin to fully separate surfaces; additive chemistry carries the protective load.
cSt (centistoke)	The standard unit of kinematic viscosity used in lubricant technical data sheets.
Demulsibility	A fluid's ability to separate cleanly from water rather than forming a stable emulsion.
Dropping point	The temperature at which a grease loses its structure and becomes fluid.
Extreme pressure (EP) additive	A sulphur-phosphorus chemistry that reacts under heat and pressure to protect surfaces under very high, shock, or boundary loads.
Flash point	The lowest temperature at which a lubricant's vapours will ignite in the presence of an ignition source.
Four-ball test	A standardised bench test (ASTM D4172 / D2783) measuring a lubricant's anti-wear and extreme-pressure performance.
Hydrocracking	A refining process using hydrogen, heat, and pressure to remove impurities and produce Group II/III base oils.
ISO VG	The ISO Viscosity Grade system used to classify industrial lubricants by kinematic viscosity at 40°C.
NLGI grade	The National Lubricating Grease Institute scale (000–6) describing grease firmness/consistency.
Oxidation stability	A lubricant's resistance to chemical breakdown from exposure to oxygen, heat, water, and catalytic metals over time.
PAO (Polyalphaolefin)	A Group IV synthetic base oil manufactured by the catalytic polymerisation of alpha-olefins.
Pour point	The lowest temperature at which a lubricant will still flow.
SAE grade	The Society of Automotive Engineers viscosity classification system for engine and gear oils (e.g. 15W-40).

Term	Definition
TAN (Total Acid Number)	A measure of a lubricant's acidity; rising TAN over time indicates oxidative degradation.
TBN (Total Base Number)	A measure of an engine oil's reserve alkalinity available to neutralise acidic combustion by-products.
Thickener	The soap or non-soap gelling agent that suspends base oil within a grease's fibrous structure.
Viscosity	A fluid's resistance to flow; the most fundamental physical property of a lubricant.
Viscosity Index (VI)	A unitless number describing how much a lubricant's viscosity changes across a temperature range — higher is more stable.